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AUTHOR Magill, Richard A.
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ABSTRACT

In an effort to clarify understanding of the concept of critical learning periods, this paper discusses problems that people concerned with the motor development of children have had determining relationships between critical periods and learning, and a "readiness model" is offered as a solution that could enhance understanding of critical learning periods. The author states that the first step in developing an understanding of the meaning and implications of critical learning periods is to realize that the concept of a critical period for learning is but one of at least three critical periods that affect development (emotional, social, and learning). In this paper, attention is directed primarily to the consideration of critical periods as they relate to learning and, specifically, the learning of motor skills. Three views on the determination of the onset of critical (optimal) learning periods are presented and diagrammed on a continuum. The extreme left side of the continuum indicates maturation as the primary determinant, the view of McGraw and Gesell. The extreme right indicates learning as the primary determinant, the view of learning theorists Gagne, Skinner, and Bruner. In between is the adaptation theory of Piaget. It is stated that no conclusive evidence supports any one of these approaches over another. The author adopts a viewpoint that seems compatible with the whole range of research evidence--critical periods for learning are considered as optimal readiness periods. The readiness model indicates three areas of concern in the determination of the onset of an optimal readiness period: (1) the physical and cognitive ability of the child; (2) the skills already possessed by the child; and (3) the motivation of the child. The model implies that critical periods of learning should be properly viewed as periods of optimal readiness and should be used as essential guidelines in the selection of activities to be taught. (MM)

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CRITICAL LEARNING PERIODS AND PROGRAMS OF EARLY INTERVENTION

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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Richard A. Magill
Texas A&M University
College Station, Texas

(Paper presented at the Motor Development Symposium, Mobile, Alabama, March 18, 1976)

"Critical learning periods" has become a phrase in the language of people concerned with the motor development of children that has been often misunderstood, misused, and even over-used. Some of this difficulty may stem from the lack of cohesive viewpoints concerning the relationship between critical periods and learning. Further problems may develop from attempting to conclude anything definitive concerning the determination of critical periods, that is what determines their onset and their duration. Perhaps even more confusing is trying to formulate satisfactory generalizations relating to preparing for critical periods, and making-up for not presenting what supposedly should have been taught during these so-called critical periods. It will be the purpose of this paper to discuss these problems and to present possible solutions to them to enhance our understanding of critical periods of learning.

The first step in developing an understanding of the meaning and implications of the concept of critical learning periods is to understand that the concept of a critical period for learning is but one of at least three types of critical periods. Each type appears to have its own meaning, means of

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determination, and implications. Articles by Scott (1962) and Bronson (1965) have identified these three critical periods from different viewpoints and should be consulted for further discussion.

Briefly, the three types of critical periods are critical periods affecting: (1) emotional development; (2) social development or the formation of basic social relationships; and (3) learning. (See Fig.1). Clearly, the bulk of the research related to critical periods has been in the area of critical periods for social development. Primarily, this research has been animal research, beginning with the famous imprinting studies conducted by Lorenz in 1935. It must be remembered that the implications developed from these studies concerning development of primary social attachments are not necessarily generalizable to critical learning periods. Unfortunately, this generalization is often made and adds to the confusion concerning the meaning of critical learning periods.

While not considering the distinctions among the types of critical periods can lead to misdirected inferences, so can the extreme approach that there is little or nothing to be learned from any critical period research other than that research directly oriented to learning periods. The distinctions among the three periods must be kept in mind as should the existing overlapping of these periods. For example, in each of the three types of critical periods, the role of learning is noted. The degree of that involvement is a critical question. However, for this address, our attention will be directed only to the consideration of critical periods as they specifically relate to learning, and more specifically, to the learning of motor skills.

McGraw (1935) is generally credited with first noticing the phenomenon of critical periods of learning in children (Scott, 1962). Her studies of Jimmy and Johnny are infamous to any who have studied motor development. She

pointed out that for certain activities, such as walking, early practice was no help in the child's learning to walk. This specific finding was later supported by Dennis and Dennis (1940) in their investigations of the Hopi Indians. McGraw further concluded that in other areas, such as roller skating, early practice was beneficial. Thus, she concluded that critical periods for learning vary from activity to activity, that is, for each motor skill there exists an optimum period for rapid and skillful learning.

The immediate question that arises is: what determines that optimum or critical period? Is it maturation, prior experience, some combination of maturation and experience, or what? Seefeldt (1975) and Gagné (1968) have provided good discussions of this problem. We shall briefly consider the alternatives here and then move on to what I consider to be the major issue to be discussed in this paper -- a realistic meaning of critical learning periods as applied to the learning of motor skills and the implications of that meaning.

In a later work, McGraw (1945) committed herself on the issue of the determination of critical learning periods by stating that beginning training before "adequate neural readiness is . . . wasted effort (p.128)." Thus, from this point of view, the role of maturation is seen as primary in the determination of the onset of critical learning periods. As evidence for this position, McGraw reported the results of an experiment in which a 12 month old child was trained daily for seven months to ride a tricycle. She concluded that the result of this effort curtailed "natural interest and enthusiasm which would have been obtained had the activity been delayed until the child was more mature (p.128)."

McGraw was certainly not alone in this maturationist viewpoint. In fact, she was in solid agreement with the leading developmental theorists of her day. Theorists such as G. Stanley Hall (1921) and Arnold Gesell (1928) had proposed developmental theory that has since been labelled the "growth-readiness model" of development. This model proposed that certain organized patterns of growth must occur before learning can effectively contribute to development.

Gesell and Thompson (1929) supported this claim with evidence from a motor skill learning study involving a pair of identical twins. At the age of 46 weeks, one twin was given special training in stair-climbing while no training was provided for the other twin. Seven weeks later, the untrained twin did not climb as well as the trained twin. However, following only two weeks of training, or about one-third of the amount given to the trained twin, the originally untrained twin actually surpassed her sister in performance. The conclusion was that better learning with less training will result when the child is "maturationally" ready for the task to be learned. Of course a major question that must be considered here relates to what the untrained twin may have been learning during the period of no special training.

One alternative approach to a maturation explanation is one that has become perhaps the most influential in today's practices and that is the approach established by Jean Piaget. Maturation continues as a heavy contributor to development in this view but additional consideration is given to the involvement of the child's interaction with the environment as well as to the factor of learning. However, learning is given a very minor role. Flavell (1963) has pointed out that concerning cognitive development, this model might properly be labelled an "adaptive" model.

Progress in a child's development, according to this approach, is affected by the interaction of the child with his environment. New experiences are

assimilated into existing cognitive structures, which are generally maturationally determined in a sequential manner, and newly acquired structures in turn make possible accommodation to the demands imposed by the environment. Thus, the child will perform those tasks which he is capable of performing, given his developmental stage. This developmental stage, while closely tied to maturation, is not at the maturation extreme of the Gesell view. Piaget's expressed developmental stages may be facilitated in their appearance by appropriate environmental interactions.

The primary means of arriving at these conclusions has been through observational evidence. A child is presented a task and then observed as to how he handles the solving of the problem at hand. Questions are generally asked to assist in the determination of the child's understanding. Flavell's volume on Piaget's developmental psychology, published in 1963, has described and discussed many supporting studies for the Piaget model and should be consulted for further study. For our purposes, it will be sufficient to understand that maturation is still considered as a primary determinant in development although now additional emphasis is given to the factor of the child interacting with his environment. Learning serves only as a factor involved in adaptation, not in development.

A third model has been presented by Gagné and was originally developed in 1968. It has since been expanded in his book The Conditions of Learning (1970). This view weights the involvement of learning in development much more heavily than do either of the previous two models. Gagné has labelled this approach the "cumulative" model of learning. Briefly, Gagné postulated that the "child progresses from one point to the next in his development . . . because he learns an ordered set of capabilities which build upon each other in progressive fashion through the processes of differentiation, recall, and

transfer of learning (1968, p.181)." Fig. 2 presents a general sequence for this cumulative learning model.

While Gagné has developed this model primarily to be representative of learning in the cognitive domain, the basic principles presented appear applicable to learning in the motor domain. For example, a major tenet of this approach is the role of transfer of learning. Gagné stated that "any learned capability, at any stage of a learning sequence, may operate to mediate other learning which was not deliberately taught (1968, p.186)". The example that immediately comes to mind is the stair-climbing study by Gesell and Thompson. It could be plausable that the untrained twin was in effect learning subordinate skills necessary to climb the stairs. The subsequent training of that twin took less time than her sister because only the specifics of stair-climbing needed to be taught to her rather then the entire skill. Thus, maturation may not have been the sole or primary reason for the shorter training period, as Gesell and Thompson concluded, but rather the reason may have been more related to learned capabilities not specifically taught that mediated the learning of the actual task.

To summarize the three points of view that we have considered thus far, look at the continuum in Fig. 3. Presented here are the three views just discussed as they relate to factors which determine the onset of critical or optimal learning periods. The extreme left side indicates maturation as the primary determinant, the view of McGraw and Gesell. The extreme right side of the continuum indicates learning as the primary determinant, the view of such learning theorists as Gagné, Skinner, and Bruner. In between, and learning more toward the maturation end of the spectrum is the adaptation theory of Piaget.

Unfortunately no conclusive evidence exists to support any one of these approaches as over against any of the others. For example, Bruner, in a discussion of readiness for learning in 1960, began his discussion from a hypothesis

that would be related to the learning side on our continuum because he stated that no evidence existed to contradict his hypothesis, while considerable evidence was being collected to support it. It is also unfortunate that the learning of motor skills has only been considered by one of these theories, the maturation approach. If we are to generalize to motor skill learning from the other two theoretical postulations we may or may not run into problems.

The discussion of these three theoretical viewpoints leads us to a conclusion concerning the determination of the onset of a critical period of learning that was presented by Scott (1962). He had synthesized animal and human learning studies that were reported from McGraw in the mid-thirties until the writing of his article in the early sixties. His conclusion, based on that synthesis, was a "provisional general hypothesis". That hypothesis stated that "the critical period for any specific sort of learning is that time when maximum capacities--sensory, motor, and motivational, as well as psychological ones--are first present (p.955)." Thus, no one factor can be considered to be the primary determinant, rather some combination of many factors must be considered.

If neither maturation nor learning, can be considered predominant in the determination of a critical learning period, then what should be our viewpoint concerning the critical learning period? The critical period for learning cannot be viewed as one in which the beginning of learning a skill must take place or else that skill will either never be learned or be learned to the potential possible had the skill been introduced during the critical learning period. Neither can the viewpoint be taken that any skill can be taught at any time, regardless of maturation level, if the instruction and practice time are sufficient. The viewpoint that does appear possible is one that is compatible with the whole range of research evidence. That viewpoint is that some

combination of maturation and learning factors is important in the determination of the critical period. The factors and the weightedness of those determining factors become vital to this definition.

Based on this discussion then, it seems only feasible to consider "critical periods for learning" as "optimal readiness periods for learning". This phrase connotes that there exist periods of time in a person's life when that person is optimally ready to learn a given skill. Seefeldt (1975) stated that "critical periods" and "sensitive periods" could be used interchangeably. A sensitive period implies that learning occurs with greater efficiency at some period in life than in others. Thus, the key issue in understanding critical learning periods to the consideration of when a person is ready to learn.

We are still left with the problem related to the factor or factors which determine this period of optimal readiness. However, we have an advantage viewing critical learning periods from this readiness point of view. Concern can now be directed to consider those factors necessary within any individual or related to a given situation for optimal learning to occur. This concern rather than directing attention at the period of life when a skill must first be introduced permits more flexibility in the presentation of instruction. With this view, many critical learning periods may exist in the same individual's life for the same skill. In fact, in certain instances, the optimal readiness may be manipulated, thus encouraging early training in certain cases as well as encouraging training in certain skills following early deprivation of experiences.

Before developing this viewpoint further as it relates to early intervention of training, time must be spent on answering the fundamental question raised earlier concerning the determination of the optimal readiness period.

Since support can be provided to suggest the inclusion of both maturation and learning as determining factors in a readiness model, the question remains concerning the inclusion of other factors. The one factor that stands out among all possible others is motivation. No learning theorist would suggest that any learning can occur without some degree of motivation to learn being present within the organism. That motivation may have been externally induced or internally generated, but its presence remains a necessary prerequisite for learning.

Thus, the readiness model being suggested here states that the period of time during which the introduction of a skill to be learned will result in the achievement of the greatest potential for performance and/or learning is that period of time when the maturation level, prior experiences or learning, and motivation of the individual are optimum for the skill to be learned. The weightedness of any one factor in determining the onset of these optimal periods will vary from task to task for the same individual. (See Fig.4). Notice then, that this model is both individual and task specific. If we consider, for example, the prior experiences portion of our model, this specificity suggests that learning to throw a baseball at a catcher is a task which child A is ready to learn, however, for child B of the same age, there are some prerequisite skills needed to be acquired. Thus, the readiness of child B is to learn a subordinate skill, which child A has already acquired. The same type of example could be developed for the other two parts of the readiness model.

In effect, this is what McGraw was suggesting in 1935. The examples she presented were walking as compared to roller skating. For Jimmy and Johnny, early training in walking was not beneficial while early training in roller skating was beneficial. Although McGraw considered the major factor in determining when to introduce any new skill to be maturation, she included the use

of instruction. Instruction at the proper time for certain motor skills could be most beneficial. However, McGraw only ever considered the acquisition of a whole skill, rather than giving consideration to the potential effect on efficient acquisition of instruction in teaching certain subordinate parts of the skill.

Another example is the one discussed earlier from the study by Gesell and Thompson using stair-climbing as the skill to be learned. Remember that these authors attributed poor acquisition to introducing instruction in the skill before the children were maturationally ready. While this is probably quite true, the model being presented here might also be considered. Perhaps these children had not adequately learned subordinate skills necessary for the acquisition of the skills being taught. Should this have been the case, then not only would it be possible to attribute poor acquisition to maturation problems, but also to the other two factors in our readiness model. The children did not have the adequate prior experiences necessary to learn the skill being introduced and were therefore probably not adequately motivated to learn them at that time.

To carry this one step further, the later rapid acquisition of stair-climbing by the previously untrained child was probably somewhat due to an increase in maturation. However, this untrained child was permitted time to explore the stairs on her own. It is possible that during that time, needed prerequisite skills were learned by the child, without benefit of the specific training provided her sibling. When the experimenters began training her to climb the stairs, the training period was much less not due only to maturational development but also to prior experiences and a more appropriate level of motivation to learn the skill.

A question may be developing concerning the meaning of prerequisite or subordinate skills. Gagné provided an early example using conservation of

quantity. Conservation of quantity is considered to be the ability to be able to see two equal-size beakers filled with the same amount of liquid poured into two other beakers of differing sizes and still be able to state that both contain the same amount of water. Piaget adherents attribute this ability primarily to maturation or to achieving a developmental stage of cognitive ability. Gagné presented his alternative view by stating that perhaps the child is unable to conserve because he has never learned necessary prerequisite a specific developmental stage. Fig. 5 shows Gagné's breakdown of conservation. Note its hierarchial nature. An inability to perform at any level below those above it would generally point to an inability to perform the ultimate task.

In the psychomotor domain, an example of this hierarchical task analysis has been presented by Singer and Dick (1974). This breakdown can be seen in Fig. 6.

To this point then, the intermix of maturation and prior experiences or prior learning should be evident. Neither can stand alone to explain the onset of optimal readiness. For certain skills, such as walking, there is ample evidence to show that maturation is a more determining factor. But, for a more complex skill such as roller skating or batting, evidence, both empirical and theoretical would show prior experience to be a more powerful determinant. The relative influence of both maturation and learning in their effect on achievement on a complex skill is a topic of much debate and worthy of much investigation. However, for this discussion, it should be sufficient to indicate that for initial learning, the attainment of prerequisite skills is of utmost priority.

The role of motivation in this readiness model needs further development. Motivation is here being defined as anything that acts an an energizer of per-

formance. Just as a battery-driven toy needs a battery to make the toy operate, so does the human organism need some energizer to be able to perform in a situation where learning must occur. However, that energizing does not always have to originate from within the individual, as might be inferred from the toy and battery example. Adequate motivation to learn might be from within the individual and be very task related or it may be induced from an outside source or be socially related. That is, the learner may begin to learn because of outside inducements, such as rewards or punishment threats, or because of social motivation factors such as needs for affiliation social approval, esteem, and so on.

Ausubel stated in 1968 that "the causal relationship between motivation and learning is typically reciprocal rather than unidirectional (p.365)." While he suggested not postponing instruction when the learner is "unmotivated", he did suggest the need for adequate motivation for optimal learning. He also reasoned that simply being introduced to the learning situation may be a way of arousing the necessary motivation level.

One inference that cannot be made from this discussion is that no learning will go on if motivation is absent. Postman in 1964 concluded after a series of studies related to short-term memory that learning does go on in an "unmotivated" condition. This type of learning has been labelled "incidental learning" and must be considered as a valid part of the learning process.

It should be clear then, that when we consider the problem of determining the onset of an optimal readiness period for learning a motor skill, there are at least three questions that must be considered. One of these questions considers what is the physical, cognitive, and emotional maturational level of the individual. The second question determines the prerequisite skills the learner is able to perform. Finally, the motivational level of the learner must

be considered. Each of these questions must be answered in relation to the skill to be learned. If any of these questions cannot be adequately answered for the task at hand, then appropriate measures must be taken to compensate for deficiencies. This compensation may take the form of changing the task to one that involves the learning of one which the person has the physical or mental ability to begin to acquire. Another compensation may be to change the task to one that involves the learning of a needed subordinate skill. Or it might be that the compensation involve employing an appropriate method to motivate the learner to begin to learn the task.

The obvious difficulty at this point is to be able to provide concrete solutions to each of these questions as they relate to specific instances. This cannot be viewed as an easy task. Fortunately, or unfortunately, depending on your vantage point, this is not the purpose of this paper. However, it should be stated that establishing valid means of answering these questions for any child for any situation, is one that physical educators must begin to attempt. Teachers will generally rely on experience and intuition in the determination of readiness. We owe it to those teachers to develop more objective and concrete measures.

One further point concerning this readiness model is that the model must be considered as a logical extension of each of the three developmental theories presented earlier. Especially when each of these theories is compared to the existing research evidence concerning the involvement of maturation, learning, and motivation in the learning situation. In fact, Gagné in The Conditions of Learning presented a readiness model that put his earlier cumulative learning model into proper perspective. He stated that three major factors comprise learning readiness: (1) attentional sets; (2) motivation; and (3) developmental status. Thus the model being presented here is much in line with what has been proposed by Gagné .

What does all this mean as it relates to the problem of programs of early intervention? First of all, let us define what is meant here by the phrase "program of early intervention." In general, these programs are organized attempts at providing early experiences for young learners in given motor skills. From the readiness model presented here at least four implications for these programs seem appropriate.

First, ultimate skills to be attained by the learner must be analyzed to determine the subordinate skills involved in the performance of these skills. Programs of early intervention must be concerned with the development of these subordinate or foundational skills. The appropriateness of these skills for a given child will be related to his maturational level, not age alone; which of the subordinate skills he is already capable of performing; and how motivated he is and can become to perform the skills selected for him.

A second implication is that these programs must be oriented toward presenting the child with as broad a base of foundational skills as possible. Since prior experiences or prior learning is so important in learning, the base of experiences from which the child will eventually operate in selecting vocational or recreational motor skills will be extremely important. This broad base will also carry over into the motivational part of learning. Rarick (1961) for example, stated that the establishment of a repetoire of motor skills at an early age has a favorable influence on the attitudes that an individual takes toward his attack on new experiences.

Third, these early programs must attend to the motivation part of the model. Just as the range of early experiences influences the selection of later experience, so does early success in the performance of motor skills. To again refer to Rarick, he stated that success in bodily activities increases the probability of formation of positive attitudes toward motor skills. If the child is continually confronted with activities that he is incapable of

performing, it should be expected that his motivation level to continue to learn more complex skills will be quite low. Also, if the amount of early experiences is limited to very few activities, it should also be expected that any drive to continue to be involved in physical activity will be quite limited.

The fourth implication relates to the types of activities selected for use in these programs. In addition to there being a wide selection of types of activities, they should also be hierarchical in nature. The activities should collectively be able to be seen as developing skills that will be used in more complex skills.

These are a few implications that appear to be warranted from the readiness model that I have presented. Programs of early intervention in the learning of motor skills are intricately tied to the problem of critical periods of learning. When these critical periods are viewed as periods of optimal readiness to learn, these programs are given their proper perspective. They cannot be viewed as programs in which certain skills must be presented now or the child will never develop his full potential in that skill. Rather, they must be viewed as programs in which a variety of experiences are provided in which the skill and the child are considered together. This consideration should take the form of concern for the physical and cognitive ability of the child, the skills already possessed by the child, and the desire of the child to get involved in the skill selected.

Critical periods for learning should not be misunderstood or misused. They should be properly viewed as periods of optimal readiness and should be used as essential guidelines for the selection of activities to be taught to people of any age.

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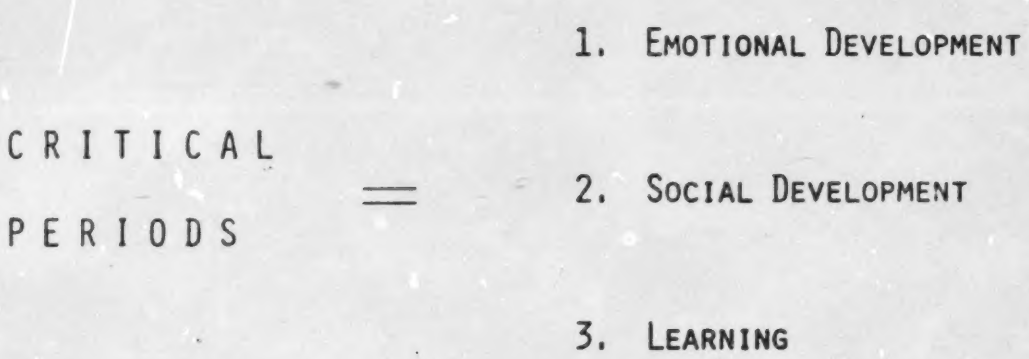

Fig. 1. Three types of critical periods

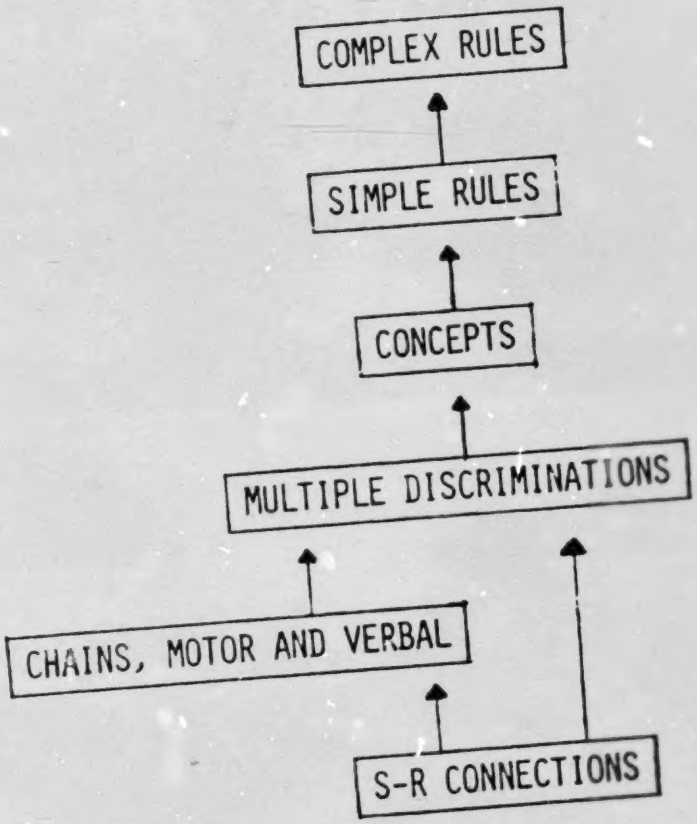

Fig. 2. General sequence of a cumulative model (Gagne, 1968)

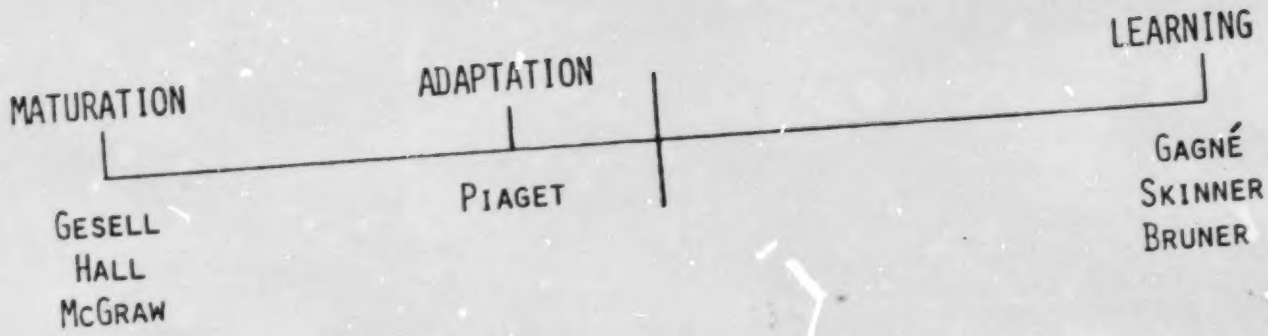

FIG. 3. CONTINUUM OF THEORIES OF DETERMINANTS OF DEVELOPMENT.

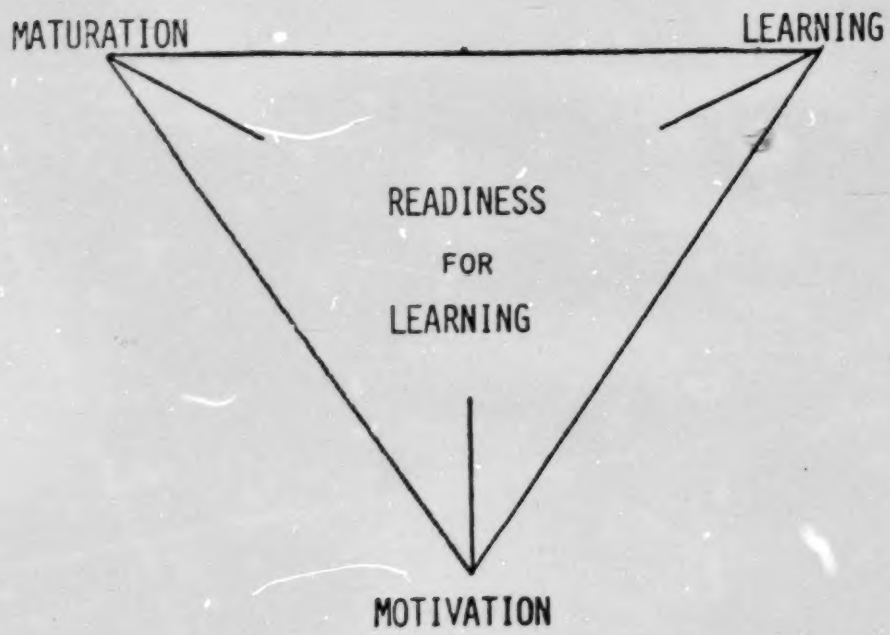

FIG. 4. READINESS MODEL.

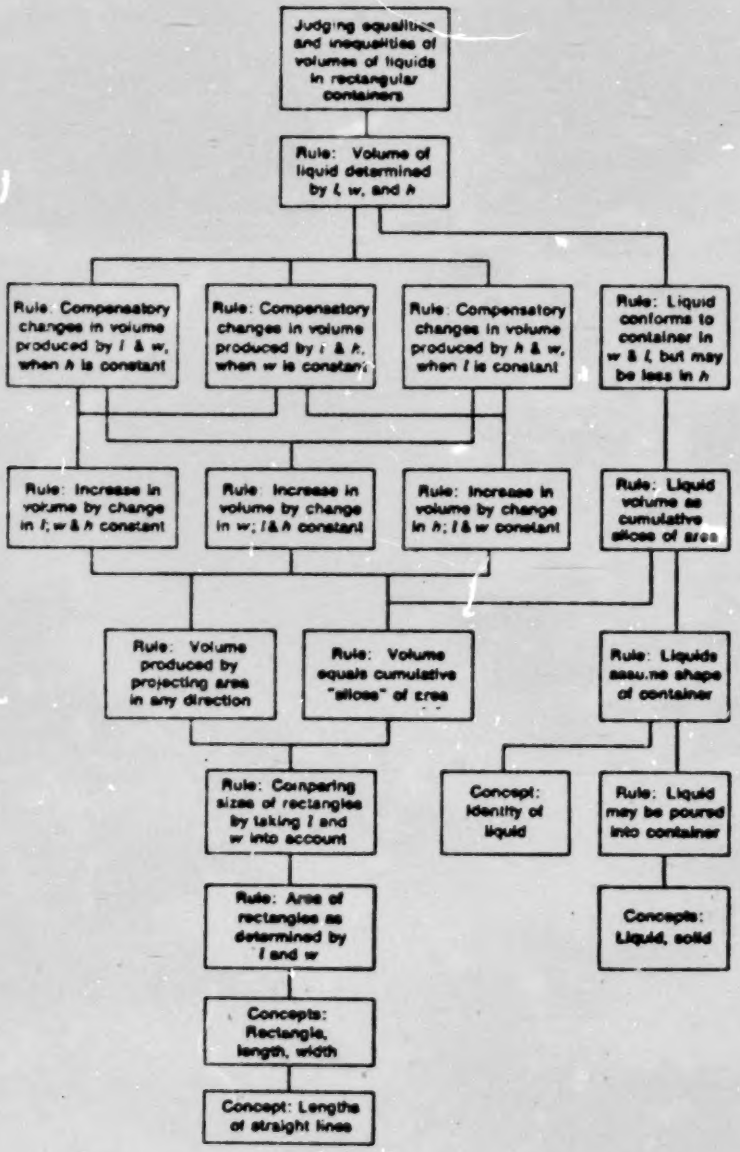
Judging equalities and inequalities of volumes of liquids in rectangular containers
Rule: Volume of liquid determined by l, w, and h
Rule: Compensatory changes in volume produced by l & w, when h is constant
Rule: Compensatory changes in volume produced by l & h, when w is constant
Rule: Compensatory changes in volume produced by h & w, when l is constant
Rule: Liquid conforms to container in w & l, but may be less in h
Rule: Increase in volume by change in l; w & h constant
Rule: Increase in volume by change in w; l & h constant
Rule: Increase in volume by change in h; l & w constant
Rule: Liquid volume as cumulative slices of area
Rule: Volume produced by projecting area in any direction
Rule: Volume equals cumulative "slices" of area
Rule: Liquids assume shape of container
Rule: Comparing sizes of rectangles by taking l and w into account
Concept: Identity of liquid
Rule: Liquid may be poured into container
Rule: Area of rectangles as determined by l and w
Concepts: Liquid, solid
Concepts: Rectangle, length, width
Concept: Lengths of straight lines

Fig. 5. Hierarchical model of conservation of quantity (Gagné, 1968)

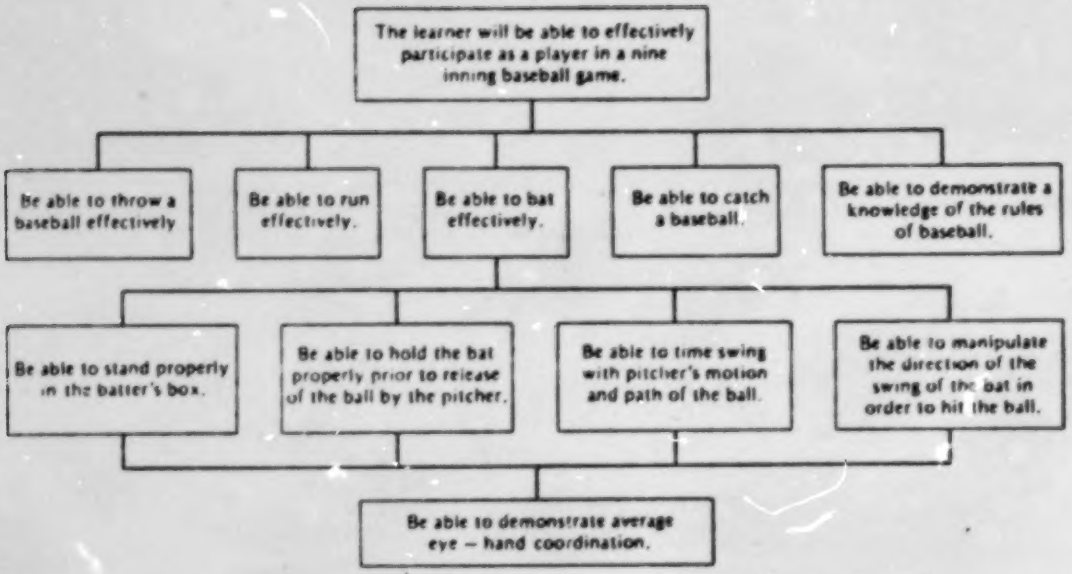
The learner will be able to effectively participate as a player in a nine inning baseball game.
Be able to throw a baseball effectively
Be able to run effectively.
Be able to bat effectively.
Be able to catch a baseball.
Be able to demonstrate a knowledge of the rules of baseball.
Be able to stand properly in the batter's box.
Be able to hold the bat properly prior to release of the ball by the pitcher.
Be able to time swing with pitcher's motion and path of the ball.
Be able to manipulate the direction of the swing of the bat in order to hit the ball.
Be able to demonstrate average eye – hand coordination.

Fig. 6. A partial learning hierarchy of a motor skill (Singer & Dick, 1974)